Road traffic impact on water quality in an urban catchment (Grigny, France): a step towards integrated traffic, air and stormwater modelling

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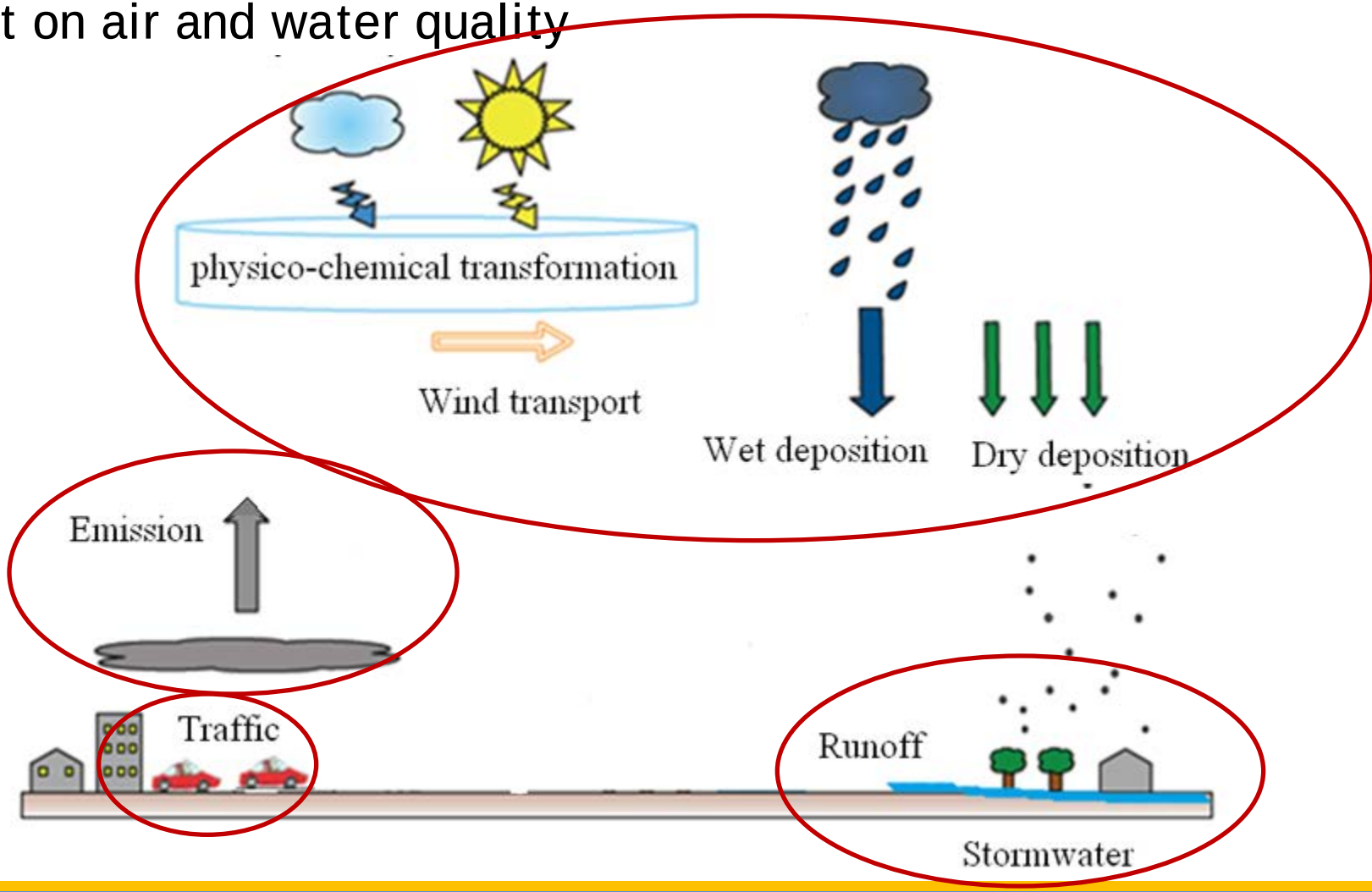
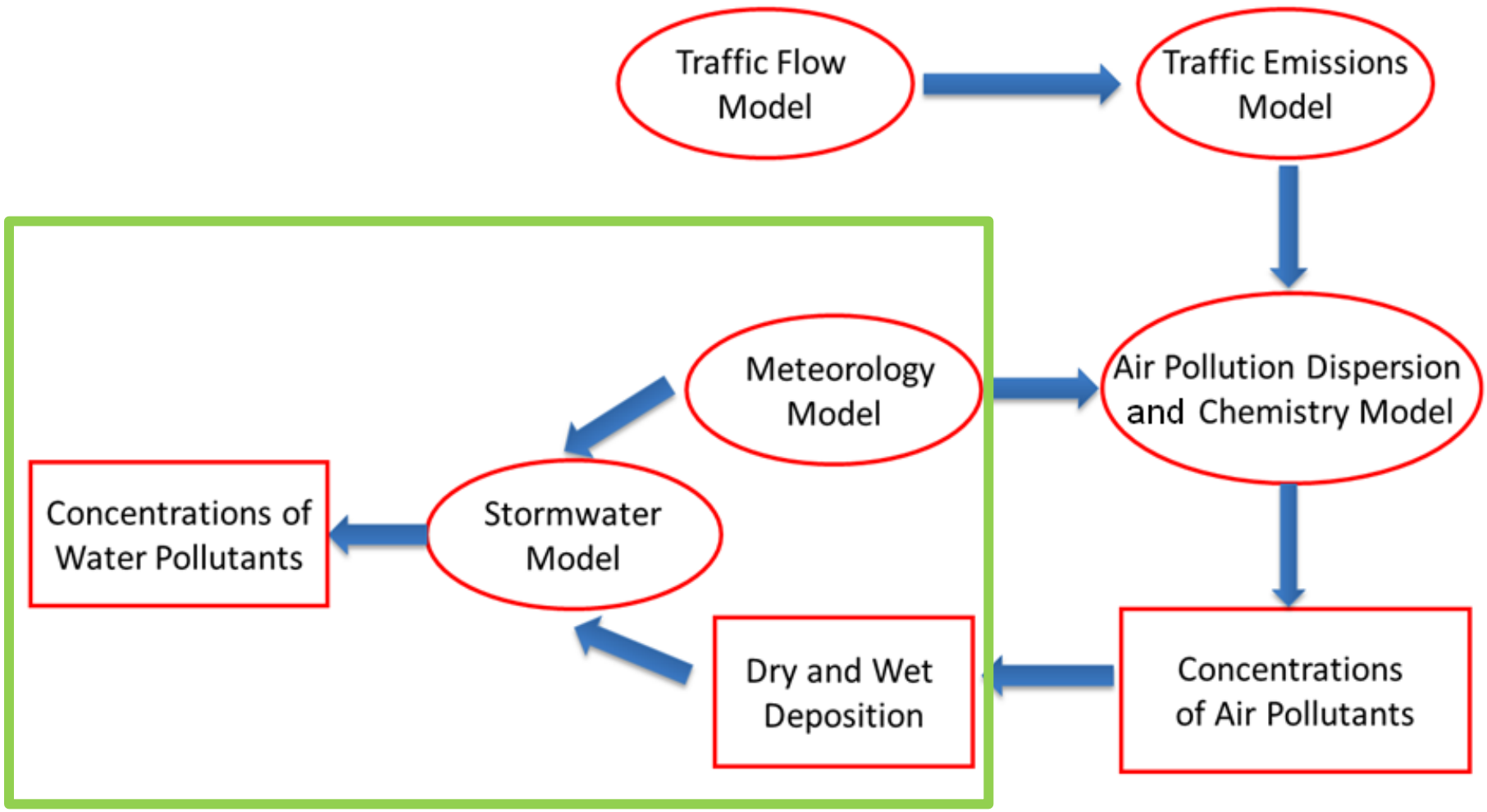
Introduction

- Objective: To create a modelling chain to estimate traffic impact on air and water quality

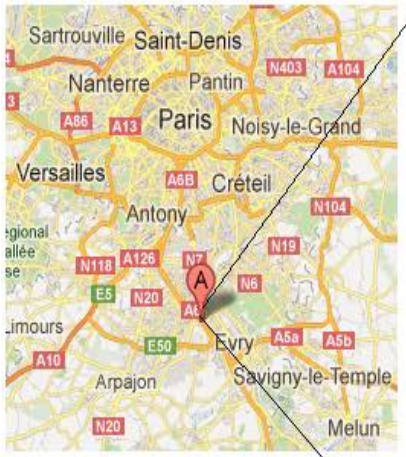


Model integration

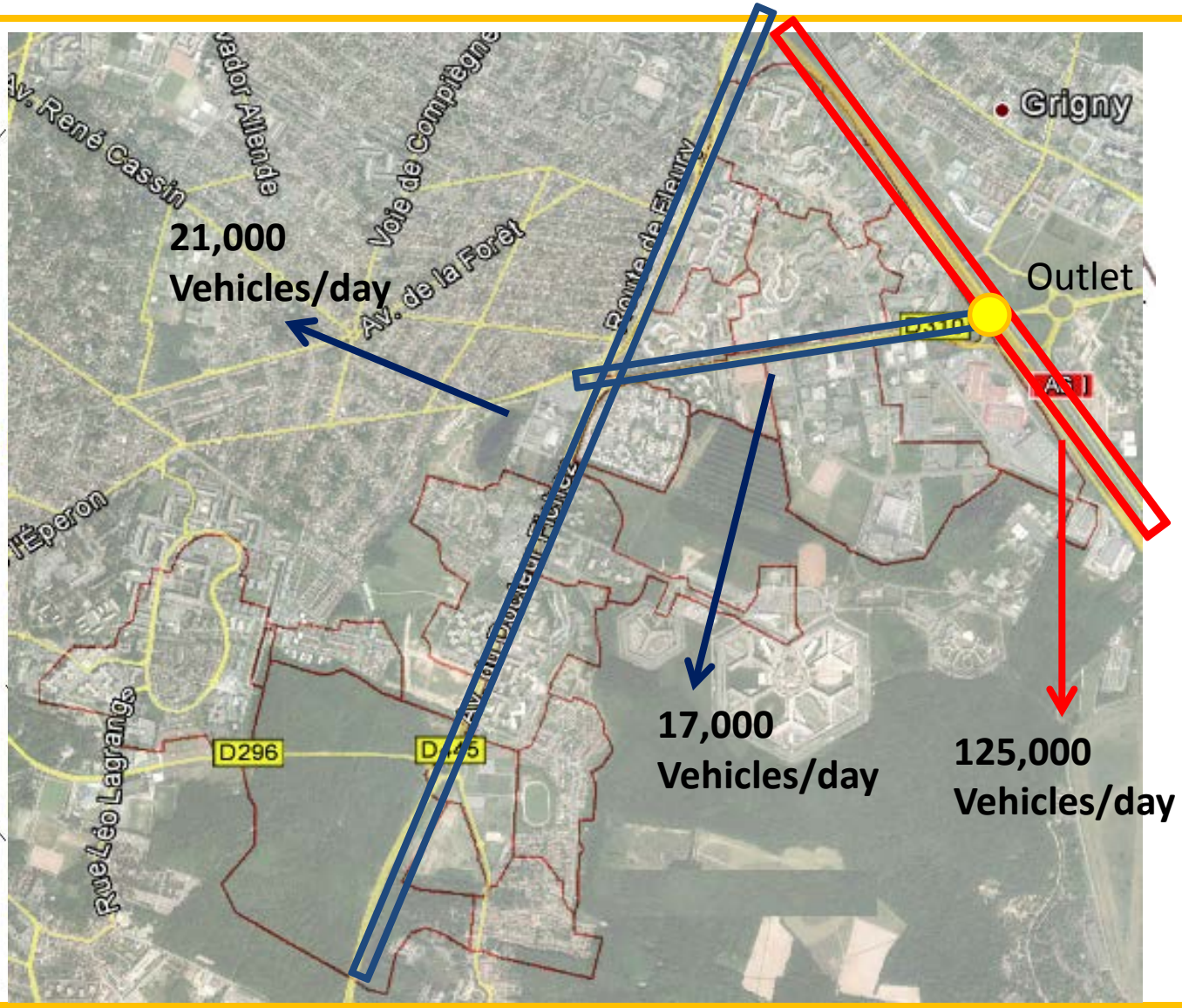


Study area

Pollutants
Cd, Zn, Pb



Grigny catchment
365.7 ha
2009-2010



Modelling tool

Quantity

Quality

Buildup

$$B = \frac{A}{C_1}\left(1 - e^{-C_1 t}\right)$$

Washoff

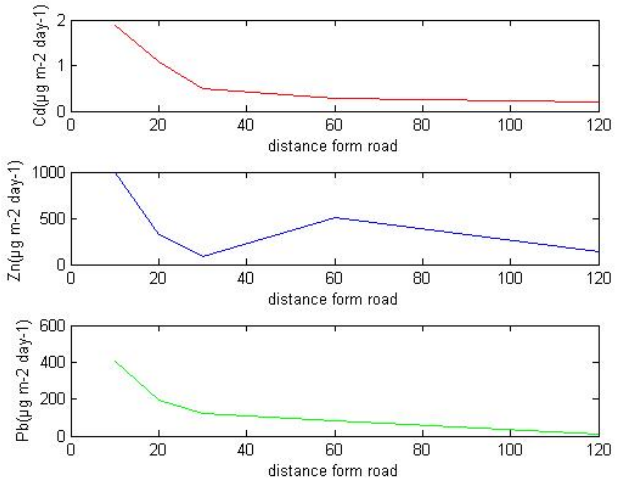
$$W = E_1 q^{E_2} B$$

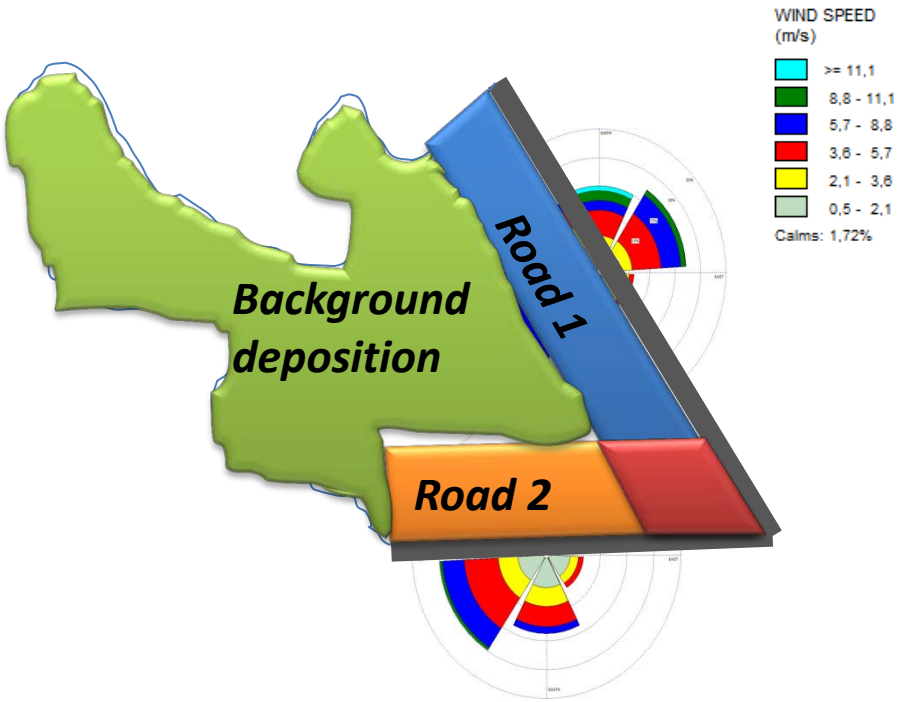
Petrucci et al. (2012).

B : pollutant buildup
W: washoff load
q: runoff rate
t: number of antecedent dry days
C_1*: removal coefficient*
E_1*: washoff coeficient*
E_2*: washoff exponent*
A: daily accumulation rate

Modelling

Daily load (µg m^{-2} day^{-1}) of heavy metals (Cd, Zn, and Pb) (Promeyrat, 2001).



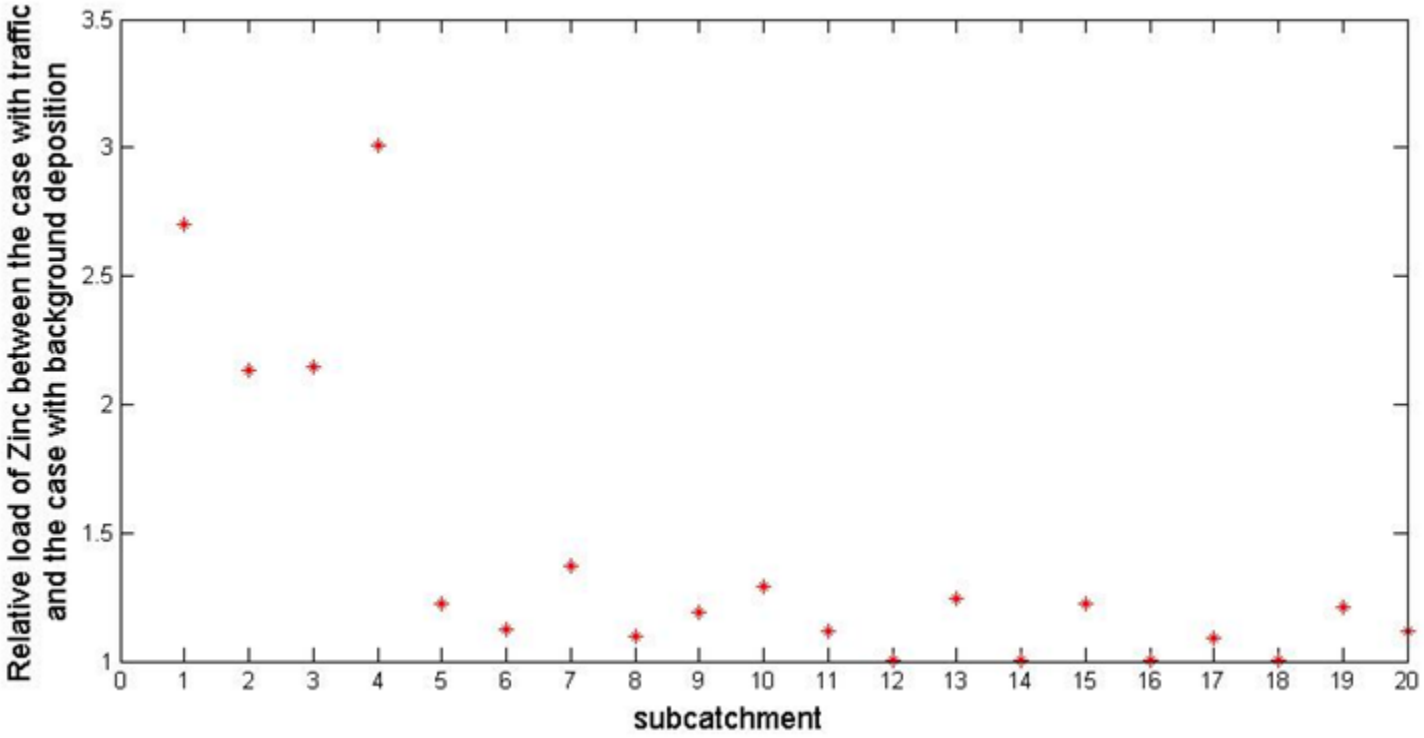


A (*daily accumulation rate*)

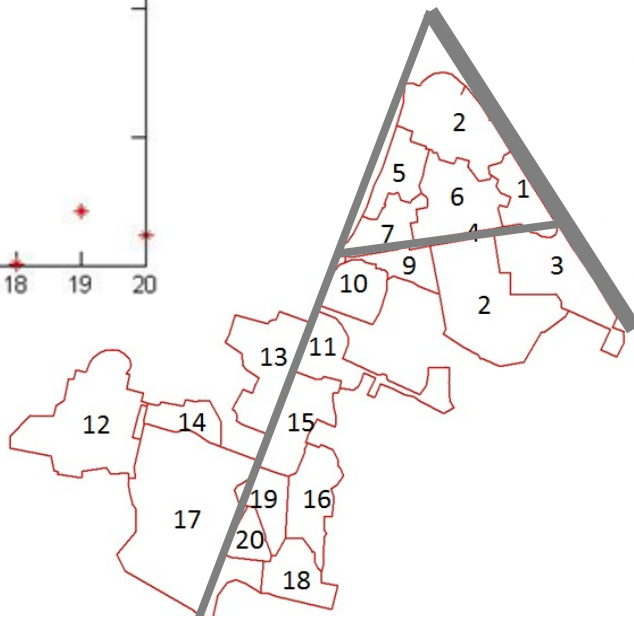
$$B = \frac{A}{C_1}\left(1 - e^{-C_1 t}\right)$$

Concentration of Water Pollutants

Results



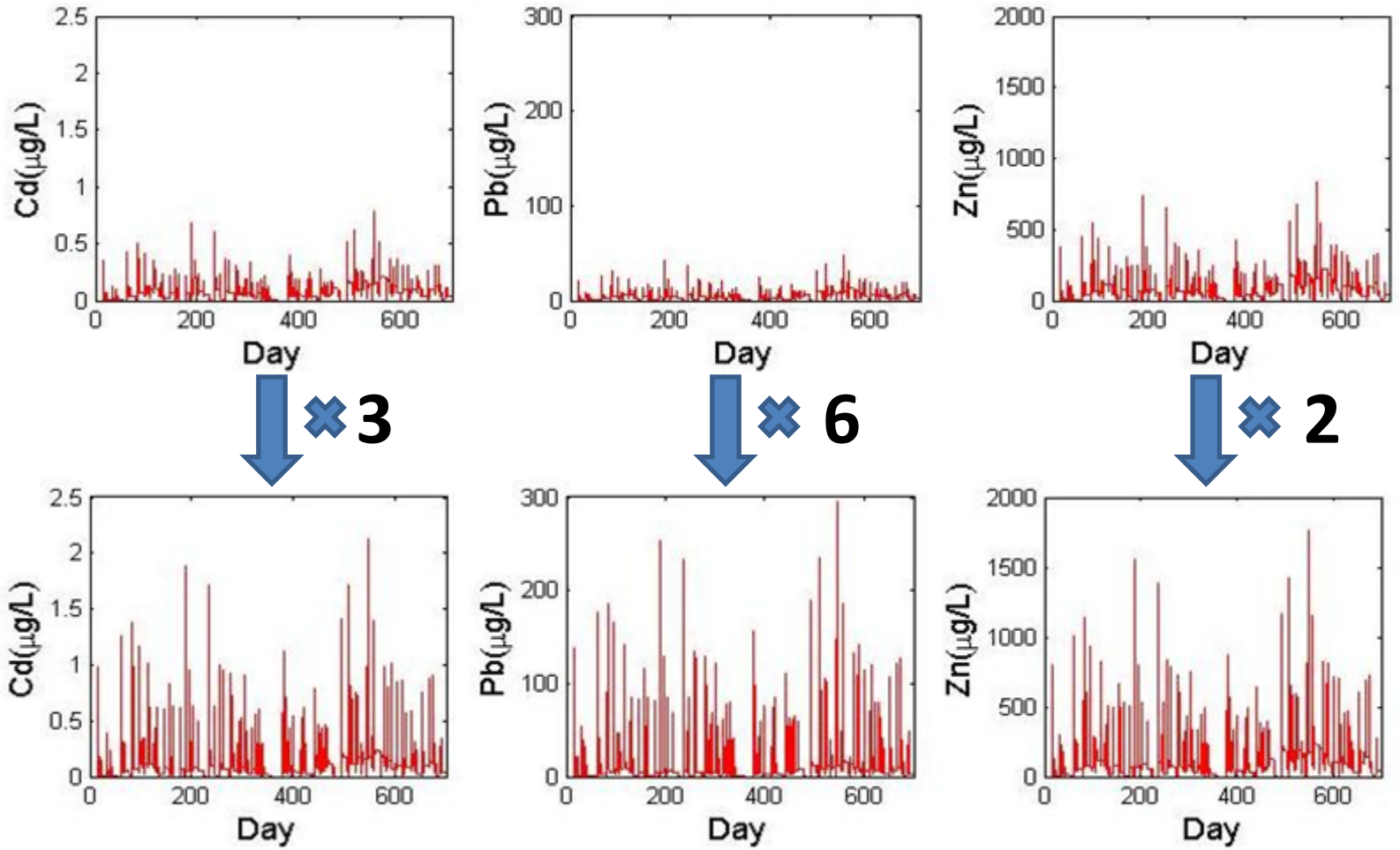
Relative load of Zn on each subcatchment between the case with traffic and the case with background deposition.



Subcatchments identified by numbers

Results at the outlet

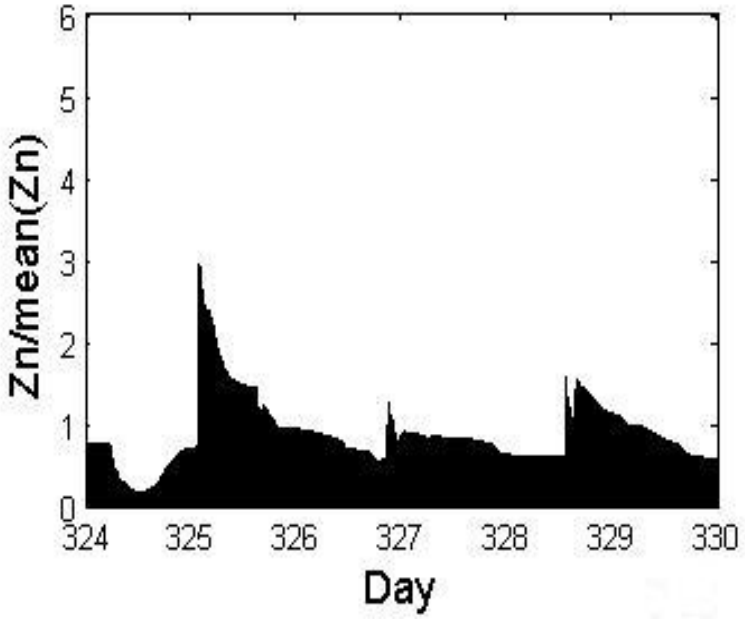
Heavy metal concentrations due to an average background deposition.



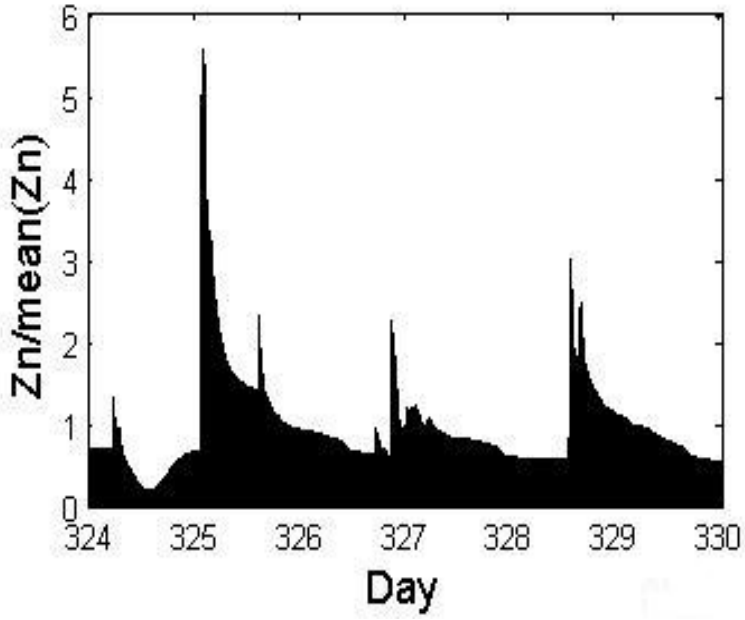
with an explicit consideration of traffic

Results at the outlet

Case with background deposition



Case with traffic on main roads

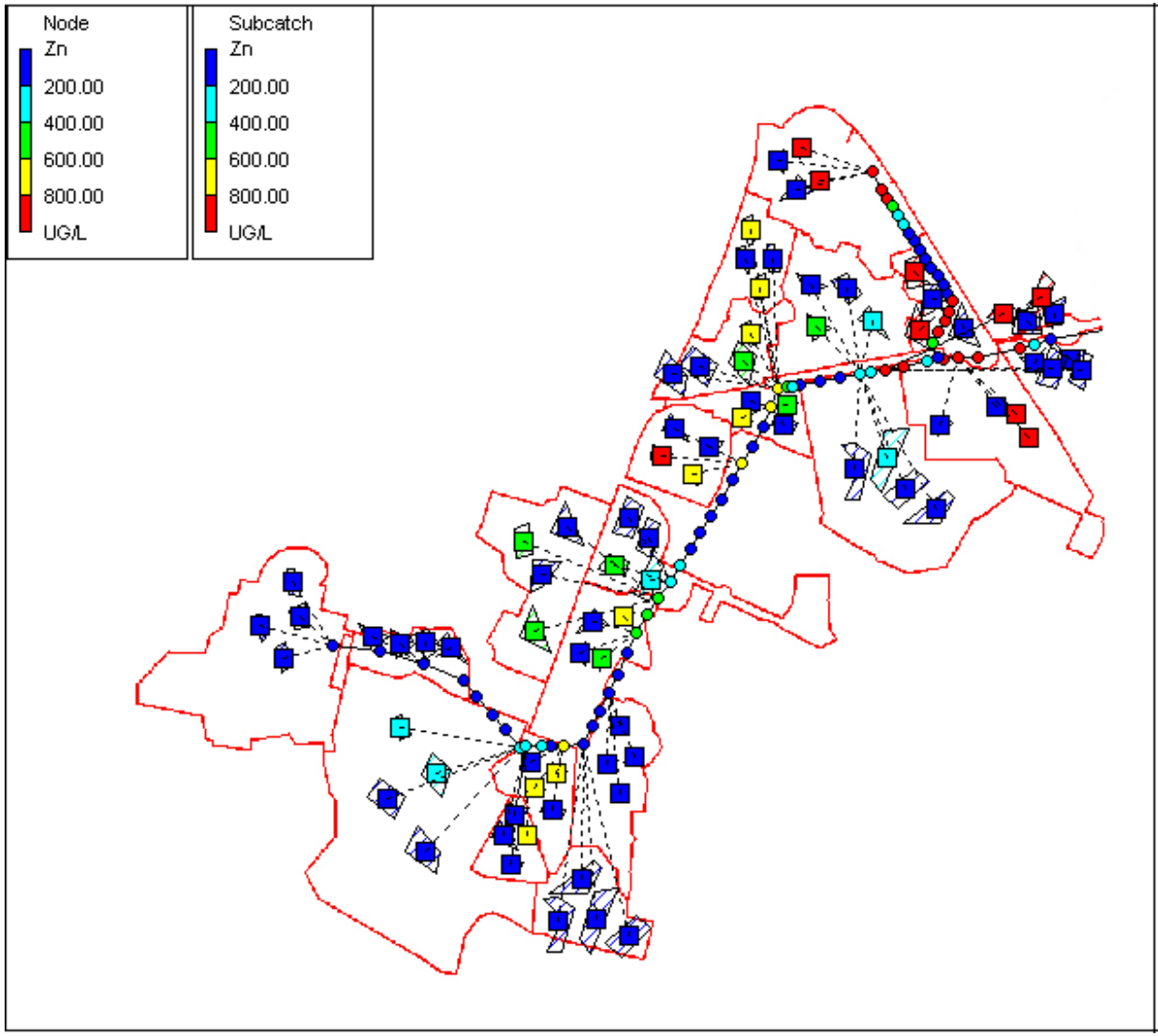


Relative zinc concentration (ratio between daily concentration of zinc and two year average concentration) over 6 days.

Spatial distribution of pollutant loadings

Spatial distribution of Zinc loadings from atmospheric deposition due to traffic at pollution peak
6:30 07/03/2010.

Highest concentration
1757µg Zn L^{-1}
284µg Pb L^{-1}
2 µg Cd L^{-1}



Sensitivity Analysis

$$S = \left| \left(\frac{x}{y} \right) \left(\frac{y_2 - y_1}{x_2 - x_1} \right) \right|$$

x is the default value of the parameter
y is the corresponding output value
x_1, x_2 are the extreme values of the parameter range
y_1 y_2 are the corresponding output values

Parameters	C_1(removal coefficient)	E_1(washoff coefficient)	E_2(washoff exponent)
Maximum Sensitivity coefficient			

Qualitative comparison with experimental data

Averaged concentrations modeled at the outlet of the Grigny catchment due to traffic over 2009-2010.

6.33 ± 4.47 µg Pb L^{-1} 79 ± 58.38 µg Zn L^{-1}

Annual mean concentrations measured by Sabin et al (2005) near a freeway in Los Angeles.

12 ± 10 µg Pb L^{-1} 160 ± 130 µg Zn L^{-1}

Conclusion

❖ Land use approach fails to produce pollutant concentration peaks at the outlet

❖ Spatial variability in exposure due specifically to roads with heavy traffic

❖ Comparison of metal concentrations in stormwater under two hypotheses (with and without an explicit treatment of traffic) shows a strong impact on pollution peaks in local urban catchment due to traffic.

Perspectives

❖ To validate the simulations with measurements at the outlet

❖ To couple with a dynamic traffic model

❖ To use a fully distributed model (Trex) for surface water flow and water quality modelling coupled to the semi distributed (SWMM) model for the urban drainage network.

Thank you for your attention

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